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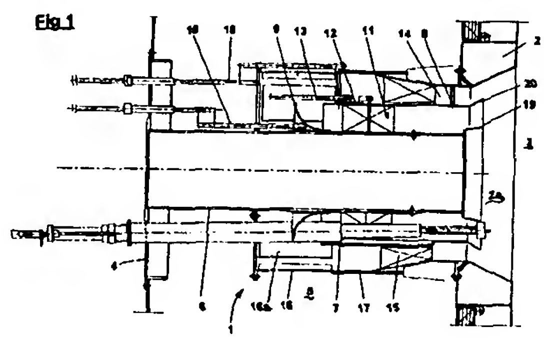
(54) Burner

(57) A low NOx burner comprising ducts for the primary (6), secondary (7) and tertiary air (14), arranged coaxially around its longitudinal axis, for supply of the primary, secondary and tertiary air, respectively, to a combustion chamber (3), means for accumulation of the air (5), means to give vorticity to the primary, secondary and tertiary air (11, 15, 27) installed in the respective ducts, means for supply of fuel (23, 32, 43) arranged within said ducts to inject the fuel into said combustion chamber. The axial swirler for the secondary air (11) is formed of a plurality of blades each of which is made up of a fixed part (11a) and a mobile part (11b) connected to actuator means capable of moving it in an angular direction to give an air outlet angle of between 30° and 60°. The axial swirler for the tertiary air is conical in shape and has fixed blades. On the tertiary air duct a passage (16) is formed for supply of secondary and tertiary air. If the burner is coal fuelled a nozzle (32) is provided in the primary duct (6), formed of a fixed annular portion divided into ducts (35) and a mobile central portion (34) to separate the air-coal mixture into jets rich in coal and jets poor in coal.

Fig.1



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Description

The present invention relates to the field of solid, liquid and gaseous fuel burners, and in particular relates to a burner providing three-phase combustion to limit the production of nitrogen oxides.

It is a known fact that nitrogen oxides are one of the most important pollutants produced during combustion processes, and are found in exhaust fumes released into the environment by steam generators, thermoelectric power stations and other industrial installations in which fossil fuels are burned. The formation of nitrogen oxides is due in part to the presence of N-compounds in the fuel (chemical NOx) and in part to the atmospheric nitrogen in the combustion air (thermal NOx). The NOx formation during the combustion process is dependent on a number of parameters, among which the main ones are the flame temperature, the time the combustion gasses remain in the high temperature zone and the excess air. More specifically, formation of nitrogen oxides increases as the flame temperature increases, and can be minimised by keeping the peak values under control. A similar effect is produced when the fuel remains in the high temperature zone for a short time and by a reducing atmosphere or an excess of fuel in the ignition area.

From what has been stated above it is clear that a combined control of the above mentioned working parameters will allow the formation of nitrogen oxides during combustion to be limited. Among the various methods suggested up to now the simplest one for reduction of nitrogen oxides directly in the combustion chamber is the stage combustion method. By suibladele dosing of the air and the fuel within the combustion system, it is in fact possible to form an area rich in fuel in the first part of the flame, where pyrolysis processes take place generating chemical compounds and radicals (OH, CN, HCN) capable of reducing nitrogen oxides. This is followed by an area in which the remaining part of the combustion air is injected to complete combustion. This alternation of zones that are rich and poor in fuel can be created both in the combustion chamber as a whole, by operating all the burners in substoichiometric conditions and providing the balance of air required to complete combustion from above the burners through post-combustion air inlets, and also in the flame of a single burner itself, so that this alternation is the concept upon which the design of so-called low NOx burners is based.

In low NOx burners of this type (see for example United States patent No. 3904349 and European patent No. 0280568) the combustion air is divided into three streams, primary, secondary and tertiary, which are fed into the combustion chamber, in a direction coaxial to the supply of fuel, through respective primary, secondary and tertiary ducts. These ducts can comprise oil lances, gas lances, coal dust injection devices, swirlers to adjust the air vorticity and to control combustion aerodynamics, as well as systems for control of the combustion air flow rate and/or exhaust re-circulation.

Another burner of the same type is described in European Patent No. 0452608 to the same Applicant, which is specially designed to burn liquid and gas fuels only, the geometry of which is capable of forming said zones of different composition: a zone rich in fuel within the flame, suibladele for the formation of reduction products, and outer zones in which the nitrogen oxides interact with the compounds and the radicals formed in the reduction zone and are reduced to molecular nitrogen.

The air is divided into three streams: the primary air, which is lightly swirled by a series of fixed blades, sbladeilises the flame against the burner. The secondary and tertiary streams are controlled by means of axial and radial registers, respectively, so as to ensure a variable ratio between the two momentums, guaranteeing control of the mixture of secondary air and fuel and accelerating the tertiary flow in order to create a large internal recirculation area. With this burner, after optimisation of the combustion system according to the type of fuel used, it has been possible to obtain reductions in NOx emission in the order of 50% as compared with traditional burners.

All the burners currently available on the market differ greatly in terms of design and structure according to the type of fuel used, gas-oil or coal-oil, respectively. In the few cases in which a three-fuel burner has been created, said burner is in any case derived from a coal-oil burner which has been mechanically, but not functionally re-adapted to hold gas lances.

In burners in which it is possible to burn solid fuel in powder form, for example coal dust, the geometry of the air-coal mixture injector nozzle is of primary importance for control of combustion and therefore for the production of NOx. In particular it is necessary to create areas that are poor in oxygen and rich in coal in the ignition area, and furthermore the time that the fuel remains therein must be such as to minimise the production of NOx and unburned substances. Finally, the re-circulation streams around the end of the nozzle must be controlled in order to avoid excessively high temperatures and local fusion phenomena, which would damage the nozzle irreversibly. In a nozzle for solid fuels of a known type manufactured by Foster Wheeler Energy Corporation, a tangential inlet for the air-coal mixture is provided to convey said mixture towards four or more ducts, whose cross-sections converge towards the combustion chamber and which are arranged in correspondence with the outlet into said chamber along an annulus coaxial with the primary air duct. In this way jets of air-coal mixture rich in coal dust are formed. Between each mixture duct and the adjacent one there is a duct with a diverging cross-section, through which air is input into the ignition area, said air being taken up through slots formed on the external shell of the nozzle. Injection of the air through these ducts is necessary in order to prevent the temperature of the nozzle from reaching exces-

sively high temperatures, but it also increases the level of oxygen in the ignition area, with an adverse effect on the reduction of NOx and therefore on the performance of the nozzle.

Finally, it should be noted that if in more recent burners the reduction of NOx emissions is satisfactory, the need for further limitation of these emissions is strongly felt and greatly desired, in view of the increasingly strict regulations adopted by various national jurisdictions to fight atmospheric pollution.

The main object of the present invention is to provide a burner with a structure suitable for the stage burning of fossil fuels, both solid, liquid and gaseous, in particular using the same construction solution for the secondary and tertiary air registers and adopting special constructive solutions in the primary air duct for injection of the coal dust.

A particular object of the present invention is to provide a burner of the above mentioned type, capable of employing, with the same air register geometry, three different fuels (coal dust, fuel oil, gas, as well as mixtures of fuels and/or emulsions) either simultaneously or in combination.

A further object of the present invention is to provide a burner of the above mentioned type that is capable of guaranteeing improved performance compared to similar known burners, in terms of a further reduction in NOx emissions.

A further object of the present invention is to provide a burner of the above mentioned type in which the load loss is reduced with respect to that of similar known burners, giving, for an equivalent fan thrust, a reduction in the diameter thereof and the ability to house it in existing boiler vents.

A further object of the present invention is to provide a burner of the above mentioned type in which the moving parts subject to setting or movement during operation are reduced to a minimum, thus increasing the reliability of the burner.

A further object of the present invention is to provide a nozzle for injection of solid fuel-air mixtures, the solid fuel being coal dust or the like, capable of giving improved combustion conditions with respect to known products of this kind.

The above objects are achieved with the burner according to the present invention, the main features of which are defined in the characterising portion of claim 1.

Further characteristics and advantages of the low NOx burner according to the present invention will become clear from the following description of a preferred embodiment thereof, given merely as a non-limiting example and with reference to the enclosed drawings, in which:

figure 1 is a partial longitudinal section view of the burner according to the invention, in which the secondary and tertiary air register assembly is shown;

figure 2 is a longitudinal section view of the oil-gas version of the burner according to the invention;

figure 3 is a longitudinal section view of the oil-coal version of the burner according to the invention;

figure 4 is a longitudinal section view of the oil-gas-coal version of the burner according to the invention;

figures 5 and 6 show an axial view and a longitudinal view, respectively, of the system for actuating the secondary air swirler;

figure 7 shows the primary air swirler installed in the burner of figure 2;

figures 8 and 9 are diagrams illustrating the performance (CO-NOx and ΔP) of the burner of figure 2 as compared with burners known to the art;

figure 10 shows a perspective view of a nozzle for coal/air mixtures according to the present invention; and

figure 11 is a partial cross-section view of the nozzle of figure 10 along arrows XI-XI.

With reference to figure 1, the secondary and tertiary register assembly for a fossil fuel burner is indicated generally with 1, arranged in correspondence with a circular opening 2a in an internal wall 2 of a combustion chamber 3. The opening 2a has the shape of a throat that opens out towards the combustion chamber 3 and the burner extends between the internal wall 2 and an external wall 4 forming a windbox 5. A primary air duct, indicated with 6, is also shown, extending from the external wall 4 and with its outlet in the throat 2a, coaxial to which is a duct 7 for the secondary air, fixed with tie rods 8 to an external and concentric duct 14 for tertiary air. The amount of air supplied to the secondary duct 7 is controlled by a disk damper 9 which slides in an axial direction until closing the inlet section of the duct 7, by activation of a control rod 10. On the duct 7 an axial swirler 11 is provided, made up of a fixed portion 11a and a mobile portion 11b capable of determining an angle of outlet for the air of between 30 and 60°.

As shown also in greater detail in figures 5 and 6, the mobile part 11b of each blade of the swirler 11 is connected to the fixed portion 11a by means of a hinge 40 integral with an arm 41, pivotally connected to the end of a tie rod 42, that extends in an axial direction from a ring 12 fitted around the duct 7 and axially sliding along said duct on activation of a rod 13 integral with the ring 12. Control of the mobile portion 11b can be either manual or automatic, to control the swirl both on start-up and during operation.

Outside the secondary duct 7 and fixed to the internal wall 2 a tertiary air duct 14 is provided concentric to the preceding one and comprising a conical axial swirler 15 with fixed blades and with an outlet angle of between 10 and 45°.

On the tertiary air duct 14 a passage 16 is provided, formed by a plurality of slots 16a for general supply of air to the burner. This passage can be fully intercepted

by means of a tubular damper 17 sliding on the outside of the tertiary duct 14, by actuating a rod 18.

From the end of the primary duct 6 feeding into the throat 2a extends a flow divider 19 having the shape of a diverging truncated cone with a suitable angle of inclination, preferably between 0° and 30°, for separation of the stream of primary air from the stream of secondary air. A similar flow divider 20 extends from the section feeding into the throat 2a of the secondary duct 7 for separation of the secondary air from the tertiary air, and has the shape of a diverging truncated cone with an angle in the range of from 30 to 60°, optionally adjustable by means of conventional lever devices, not shown, in order to adjust the outlet speed of the tertiary air and its partition with the other air streams.

The secondary and tertiary air register structure described above gives the following advantages, with respect to products currently available on the market, and more specifically with respect to the burner according to European Patent 0452608 in the name of the same Applicant:

- a marked reduction in the pressure drop, resulting from the axial arrangement of the tertiary air intake and the low level of swirl at the outlet;
- greater simplicity of construction, resulting from the elimination of the mobile blades in the tertiary air section and the consequent removal of the relative actuation devices thereof;
- easy balance of the air stream through the single burners in case of applications with a common windbox, by actuation of the register 17, which controls the flow rate of air to the burner;
- optimisation of the aerodynamic profile of the burner, which creates and stabilises an extensive area of re-circulation in the first part of the flame, giving further reductions in the level of NOx produced.

An embodiment of the structure of the secondary and tertiary air register assembly according to the invention is illustrated in figure 2 for a oil-gas burner. In figure 2 the components that are the same as those illustrated in the burner of figure 1 also have the same reference numbers.

Along the longitudinal axis of the burner a tubular guide 21 is provided for a liquid fuel lance 43 and a supply duct 22 for gaseous fuel distributed on equally spaced lances 23 arranged around the one for the liquid fuel. The lances 23 for the gaseous fuel and the one for the liquid fuel are arranged within the cylindrical duct for primary air 6 and the lances 23 are supported by intermediate tie rods 21a extending radially from the tubular guide 21. Along an intermediate circumferential portion of the duct 6 a plurality of slots 24 are formed to supply it with primary air. The slots 24 can be intercepted until completely closed by means of a cylindrical damper 25 coaxial with the duct 6 and sliding along it by means of a control rod 26.

Close to the outlet section of the primary air duct 6 a fixed swirler 27 is provided which, as shown in greater detail in figure 7, is divided into two concentric annular areas equipped with blades set at different angles on the inner row 27a and the outer row 27b and having special passages for the gas lances 23, as well as a central passage 45 for the oil lance 43.

The performance of the burner in the oil-gas version according to the present invention has been compared with that of the burner according to European patent No. 452608 and with a reference "PARALLEL FLOW" burner in the following operating conditions: 40 MWt, use of oil No. 6 with organic nitrogen 0.45%.

Figure 8 shows, in arbitrary units, the nitrogen oxide and CO emissions in the three cases, as a function of the percentage of oxygen in the smoke, whereas figure 9 shows, again in arbitrary units of measurement, the values for pressure drop versus the combustion air flow rate, measured between the air tank 5 and the combustion chamber 2 in the case of the burner according to the invention and of the one according to European patent 0452608.

From the tests carried out the following results have been obtained:

- a reduction in NOx emissions in the region of 65% without any worsening from the smoke point, with oil combustion;
- a reduction in the NOx emissions of the same extent with gas combustion;
- a reduction of over 30% in pressure drop between the windbox and the combustion chamber;
- the ability to combine the burner with any type of atomiser plate, whether steam or mechanical;
- the ability to obtain concentric combustion (oil + gas) in the whole range of possible variations in the ratio of the two fuels;
- the possibility to carry out the concentric combustion (oil plus gas) in all the variation range of both fuel;
- a noticeable simplification of the construction, mainly due to the presence of a single actuator for interception of the combustion air and elimination of all movements involving gears.

Figure 3 shows a longitudinal section of the oil-coal version of the burner as a whole. The mixture of coal dust and transporting air is fed into the central duct of the burner 6 through the coal dust transport pipe from a mill, not shown. In the figure the guide is illustrated as the most common solution of an elbow joint 28. Immediately downstream of the inlet is a deflecting wall 29 which has the job of contrasting the tendency of the coal dust mixture to collect in layers on the outside of the bend.

Positioned after this is a Venturi-type diffuser 30 having the job of rendering the mixture homogeneous,

and then a fixed swirler 31 which gives the mixture a rotational movement such as to spin the coal dust towards the wall of the primary duct 6.

The concentrated coal dust is then injected into the combustion chamber 2 through a nozzle 32 for coal-air mixtures, positioned at the outlet of duct 6.

As also shown in greater detail in figures 10 and 11, the nozzle 32 is made up of a fixed portion 33 which serves the purpose of concentrating the coal dust into physically separate streams, and a mobile device 34 which serves the purpose of registering the outflow of primary and combustion air according to the manner in which the desired combustion process is to be carried out.

The fixed portion 33 consists of a group of at least three ducts 35 with the shape of a truncated cone converging towards the combustion chamber 2, arranged around an annulus coaxial with the duct 6 and the oil lance 43, so as to transform 100% of the annulus section at the inlet into 40 - 60% of the section at the outlet. As an example, in figure 10 an embodiment with four ducts 35 is shown. In this way the coal dust, which is already collected on the outside thanks to the swirler 31, is divided into various streams with a low air/coal ratio. The coal ducts 35 define between themselves air ducts 36 of a shape diverging towards the combustion chamber 2, the outlet ports of which in this way alternate with those of the ducts 35.

The mobile portion 34, coaxial with the oil lance, has a conical cup shape and can occupy two end positions and a plurality of intermediate positions, as it is slidingly mounted thereon and is moved by means of a rod, not shown.

The primary air transporting the coal dust reaches the stationary part of the nozzle, as stated above, rich in coal dust towards the outside and poor in coal dust at the centre. It flows into the inner duct 37 of the stationary injector and divides into the side ducts 36 defined by the coal dust ducts 35, and frontally through the passage defined by the mobile portion 34 and the outlet from the inner duct 37. Inclined plates 38 are positioned at the nozzle outlet in correspondence with the outlets from the air ducts 36.

The inclined plates have the aim of deflecting the primary air, poor in coal dust, towards the outside, mixing it with the secondary air, and have an inclination of between 0 and 45°, optionally adjustable in a known manner by means of a control rod, not shown.

In an embodiment illustrated in figure 11, given as an example, the ducts for the air-coal mixture 35 are tubular sectors of an annulus with a cross section that decreases from the inlet to the outlet, which are welded at their inlet end to a support 39 made up of two concentric annular members connected by radial arms, while at their outlet ends the ducts 35 are connected by means of circumferential tie rods 46 which give adequate allowance for thermal dilation.

It is upon performance of the process of mixing the air poor in coal dust and the streams rich in said coal dust that the composition of the two-phase mixture at the burner outlet depends, and this is the basic factor for control of emission of NOx, unburned elements and flame stability.

According to the present invention, by suitably combining the position of the cone 34 with the effect of the stationary injector 33 it is possible to define an optimum solution to respond to the various requirements of different installations.

With cone 34 a long way back the flame is longer, the combustion process is slow, so that NOx is minimum, but CO and unburned elements are maximum.

With the cone 34 a long way forward combustion is intense and localised, due to the high level of coal dust/air mixing NOx are maximum, CO and unburned elements minimum.

The embodiment shown in figure 3, which has been tested at full scale, has underlined the following peculiarities:

- a NOx reduction in the order of 50%, when oil and coal are burnt, as compared with traditional "CIRCULAR" type burners;
- during coal fuelling a reduction in the level of unburned elements in the order of 50%, as compared with first generation "Low NOx" burners;
- in all cases there was always a reduction in the pressure drop in the order of 30%, again as compared with first generation "Low NOx" burners, due to the construction of the secondary and tertiary air registers.

A burner according to the invention suitable for use with both solid, liquid and gaseous fuels, either alone or in a combination of oil and gas, is illustrated in figure 4. This burner differs from the one illustrated in figure 3 essentially in the fact that a row of gas lances 23 is provided, arranged around the nozzle 32 for injection of the air-coal mixture, said lances being arranged in the duct 7 for secondary air. This arrangement, which is made possible by the configuration of the secondary and tertiary air registers according to the invention, allows the gas lances 23 to be kept in a fixed position even during coal combustion, unlike conventional low NOx burners in which each lance is equipped with a pneumatic actuator, to withdraw it during coal firing because of problems of cooling and wear.

In a special embodiment of the burner of figure 4 a pair of gas lances 23 is provided for each duct 35 for the air-coal mixture of nozzle 32, arranged for example at the two ends of the outlet of said duct.

Finally, it should be noted that the nozzle 32 for injection of air-coal dust mixtures described above can also be fitted with advantage to burners other than the one according to the present invention.

Variations and/or modifications can be made to the three stage low NOx burner capable of burning solid,

liquid and gaseous fuels according to the present invention, without departing from the scope of protection of the invention itself, as defined in the appended claims.

Claims

1. A low NOx burner comprising ducts for the primary (6), secondary (7) and tertiary air (14), arranged coaxially around its longitudinal axis, for supply of the primary, secondary and tertiary air, respectively, to a combustion chamber (3), means for accumulation of the air (5), means to give vorticity to the primary, secondary and tertiary air (11, 15, 27) installed in the respective ducts, means for supply of fuel (23, 32, 43) arranged within said ducts to inject the fuel into said combustion chamber, characterised in that said means for giving vorticity to the secondary air comprise an axial swirler (11) for the secondary air, formed by a plurality of blades each of which is made up of a fixed part (11a) and a mobile part (11b) connected to actuator means capable of angularly displacing said mobile part to give an air outlet angle of between 30° and 60°, said means for giving vorticity to the tertiary air comprising an axial swirler (15) for the tertiary air, in the shape of a cone and with fixed blades, a passage (16) being formed on the tertiary air duct to feed the secondary air and the tertiary air.

2. The burner according to claim 1, in which said means for actuation of said mobile part (11b) of said axial swirler (11) for the secondary air comprise an annular element (12) slidingly mounted on the secondary air duct (7) and integral with a rod (13) to slide it along said secondary air duct, the mobile part (11b) of each blade of said swirler (11) being integral with a respective arm (41), rotationally connected to a respective tie rod (42) extending axially from said annular element (12).

3. The burner according to claims 1 and 2, in which said means for giving vorticity to the primary air comprise an axial swirler (27) for the primary air formed by two concentric rows of fixed blades, said rows having a different inclination from the longitudinal axis and being arranged close to the outlet of said primary air duct.

4. The burner according to claim 3, in which the passage (16) formed on the tertiary air duct also supplies the primary air fed to the primary air duct (6) through an interceptable passage formed thereon.

5. The burner according to the preceding claims, in which said means for supply of fuel comprise a lance for liquid fuel (43), coaxial with the primary air duct and a row of gas lances (23) around it, said liquid fuel and gas lances being arranged inside said primary air duct (6).

6. The burner according to claims 1 and 2, in which said means for supply of fuel comprise a lance for liquid fuel (43) arranged coaxial to the primary air duct (6) and inside it, and a nozzle (32) for injection of a mixture of air and coal dust, positioned at the outlet of said primary air duct (6) and made up of a fixed annular portion divided into ducts (35) of a circumferential width that decreases towards the outlet of the duct (6) to form jets of coal dust mixture, and a central portion (34) that is axially mobile within said nozzle, capable of blocking a central passage (37) of the nozzle formed by said fixed annular portion, there being formed between two adjacent ducts in said fixed annular portion a respective duct (36) for formation of a jet of a mixture poor in coal dust, with an increasing circumferential width, deflector means for said mixture poor in coal dust being provided at the outlet from said ducts (36) to direct the jets of said mixture poor in coal dust in a direction that diverges from the longitudinal axis.

7. The burner according to claim 6, in which the inclination of said deflector means can be adjusted within an interval of between 45° and 90° with respect to the longitudinal axis.

8. The burner according to claims 6 and 7, in which the overall section for passage of said ducts (35) for the mixture rich in coal dust at the inlet of said nozzle is substantially equivalent to 100% of the section at the inlet of said fixed annular portion, whereas the overall section of the passage of said ducts at the outlet of said fixed annular portion is equal to 40-60% the outlet section thereof.

9. The burner according to claims 6 and following, in which said ducts (35) for the mixture rich in coal dust are axially fixed at their inlet ends to a support (39) formed by two concentric annular members connected to each other and radially spaced at a distance substantially equal to the radius of said ducts, said ducts being connected together by means of circumferential tie rods at their outlet ends.

10. The burner according to claims 6 and following, in which within said secondary air duct fixed gas lances (23) are fitted, arranged around said nozzle (32).

11. The burner according to claims 6 and following, in which at the outside of each duct (32) for the mixture rich in coal dust at least one pair of said gas lances (23) is provided.

12. A nozzle for injection of solid fuel in dust form into a combustion chamber, to be installed in correspondence with the outlet of a burner coaxially to the longitudinal axis of the latter, characterised in that it comprises a fixed annular part divided into ducts (35) of a circumferential width that decreases towards said outlet section to form jets of coal dust mixture, and a central portion (34) that is axially mobile within it, capable of intercepting a central passage (37) thereof formed by said fixed annular part, there being formed between two adjacent ducts in said fixed annular part a respective duct (36) for formation of a jet of a mixture poor in coal dust, with an increasing circumferential width, deflector means (38) for said mixture poor in coal dust being provided at the outlet from said ducts (36) to direct the jets of said mixture poor in coal dust in a direction that diverges from the longitudinal axis.

13. The nozzle according to claim 12, in which the inclination of said deflector means (38) is adjustable within an interval of between 45° and 90° with respect to the longitudinal axis.

14. The nozzle according to claims 12 and 13, in which the overall section for passage of said ducts (35) for the mixture rich in coal dust at the inlet thereof is substantially equivalent to 100% of the section at the inlet of said fixed annular portion, whereas the overall section of the passage of said ducts at the outlet of said fixed annular part is equal to 40-60% the outlet section thereof.

15. The nozzle according to claims 12 and following, in which said ducts (35) for the mixture rich in coal dust are axially fixed at their inlet ends to a support (39) formed by two concentric ring elements connected to each other and radially spaced at a distance substantially equal to the radius of said ducts, said ducts being connected together by means of circumferential tie rods at their outlet ends.

16. The nozzle according to claims 12 and following, in which said mobile portion (34) is a cup-shaped cone with the hollow part pointing towards the combustion chamber.

17. The nozzle according to claims 12 and following, in which a tubular housing is provided in the central part to house an oil lance.

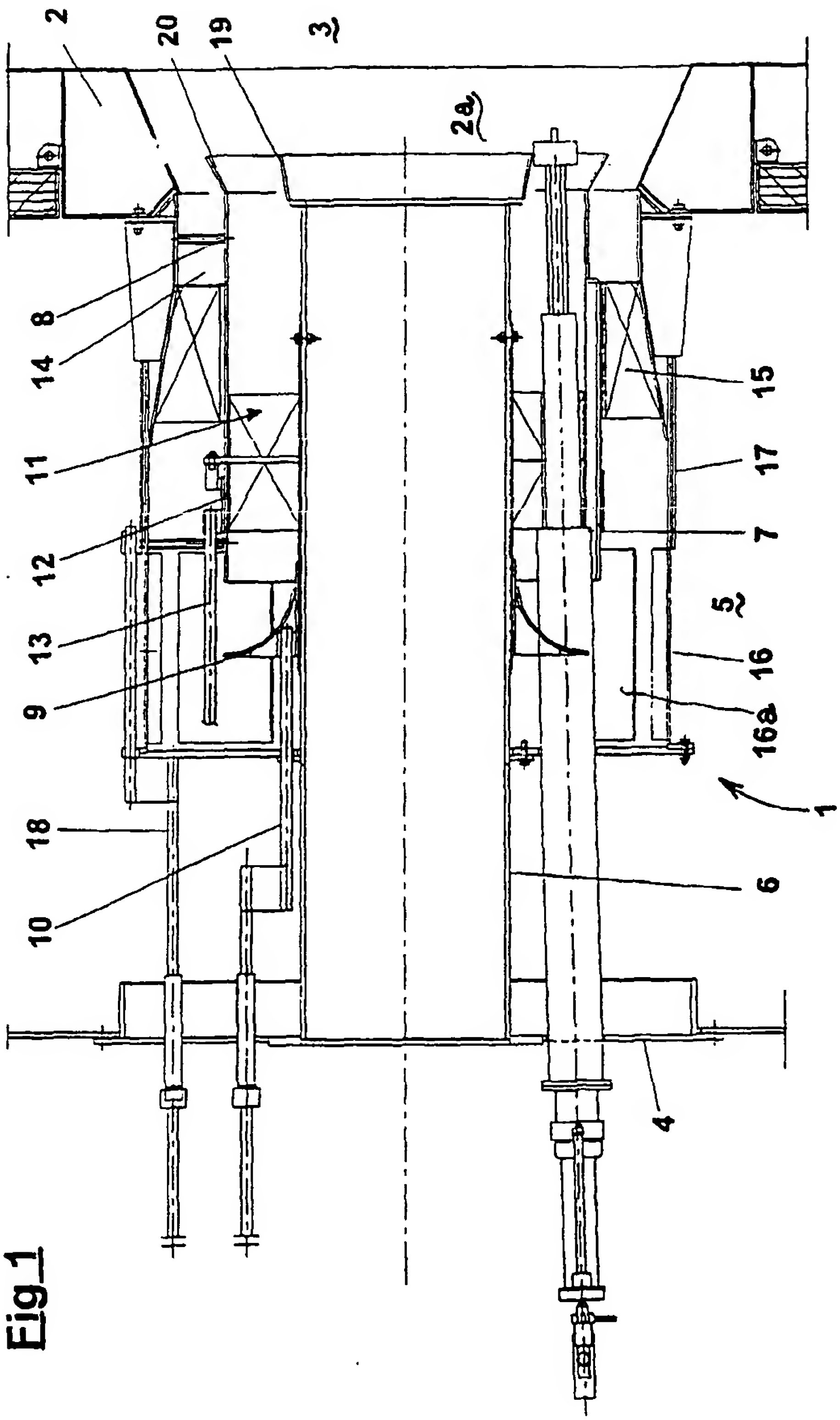

Fig 1

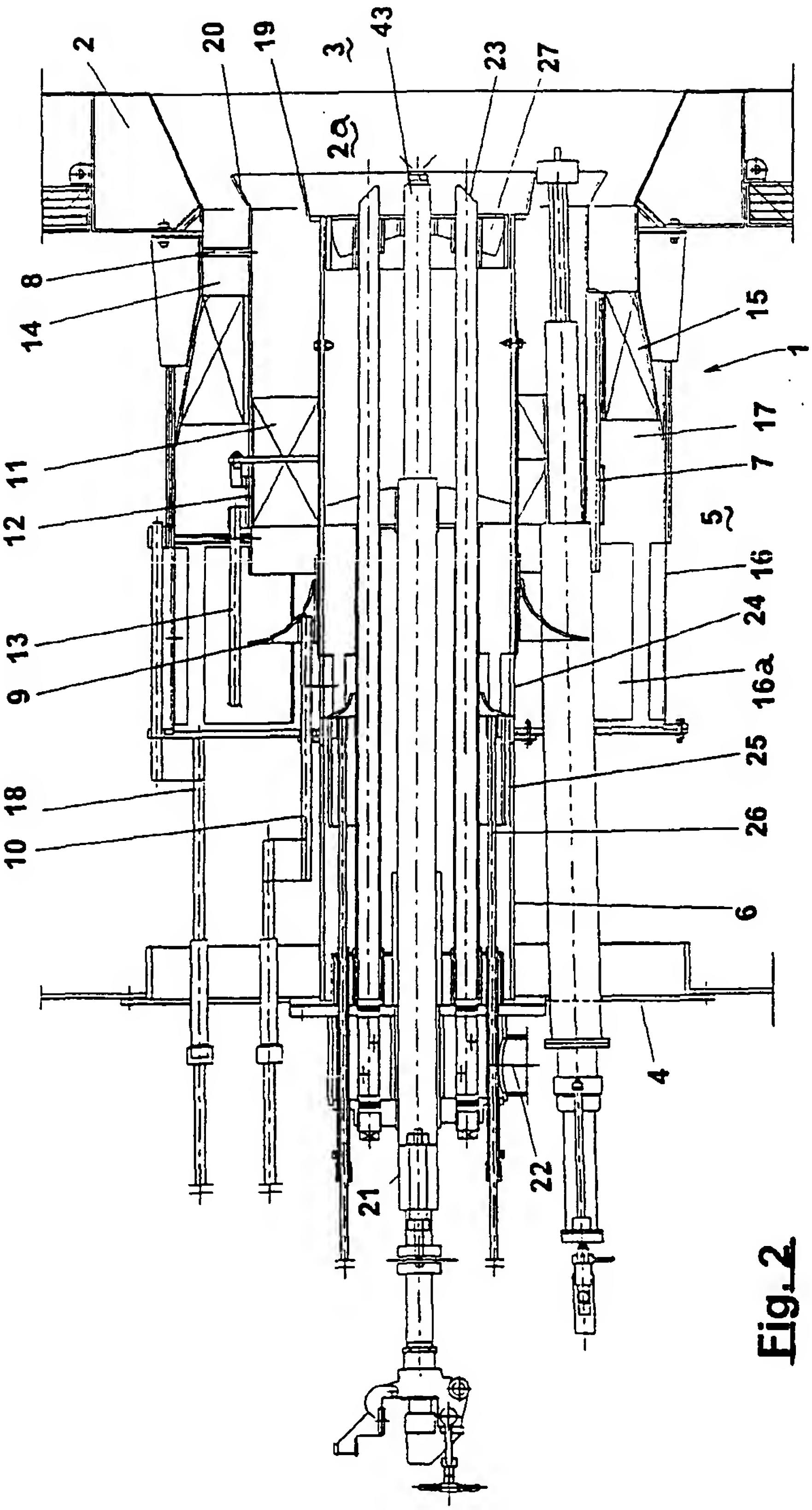
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Fig. 2

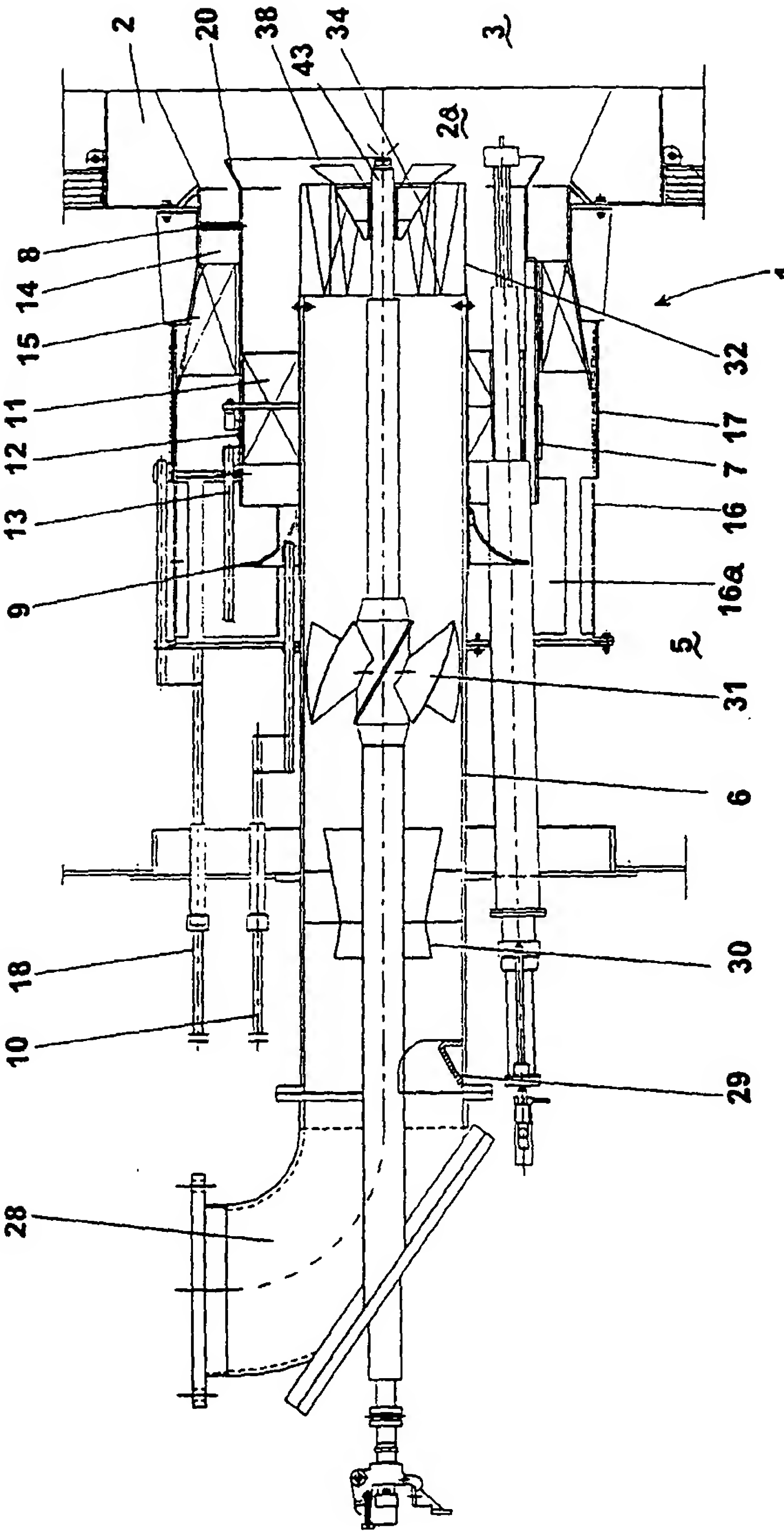

Fig. 3

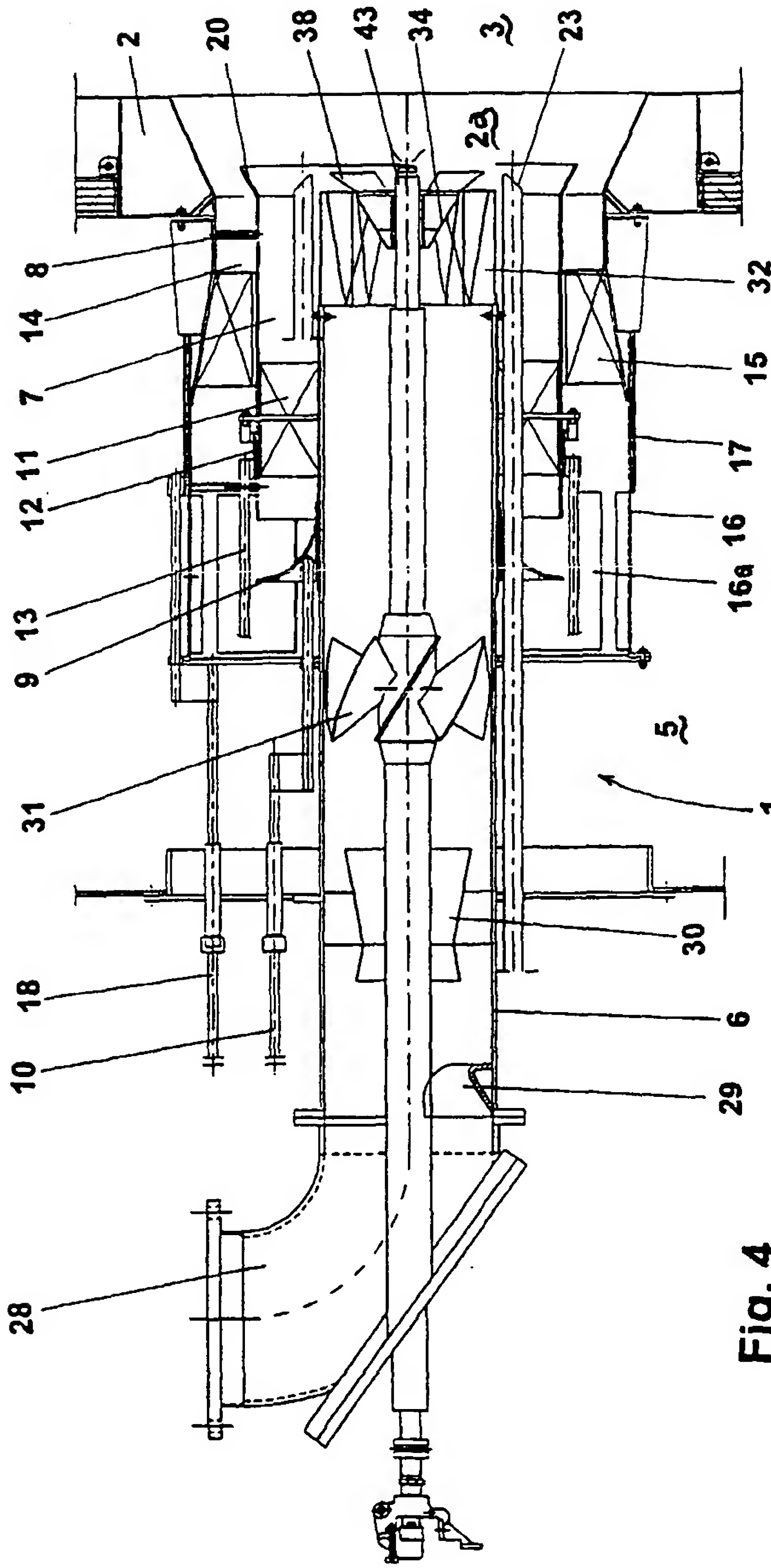
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Fig. 4

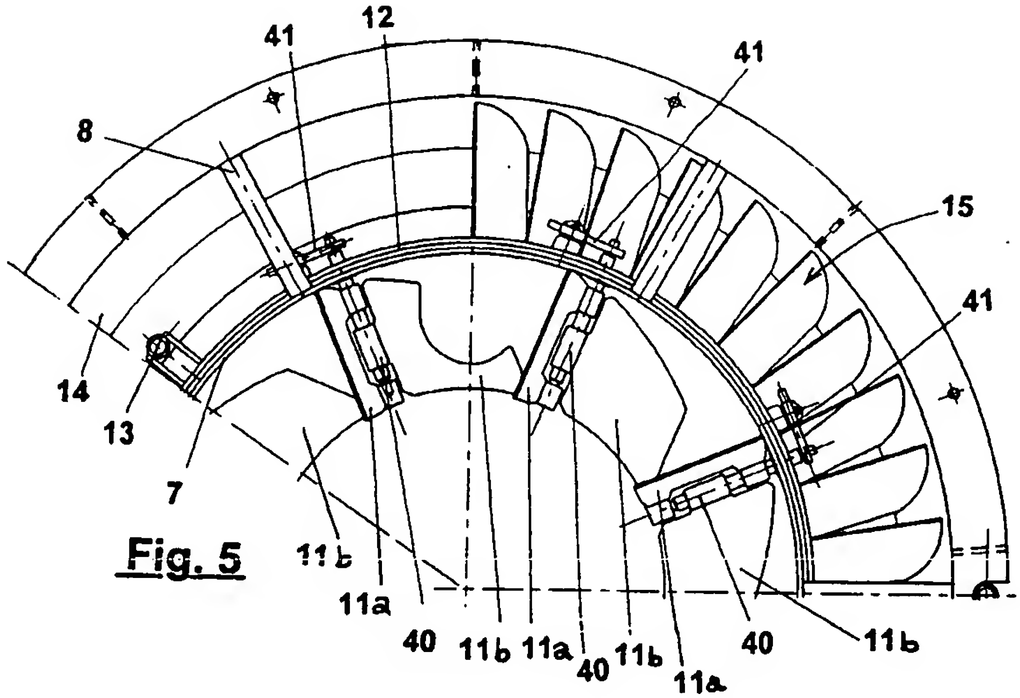
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Fig. 5

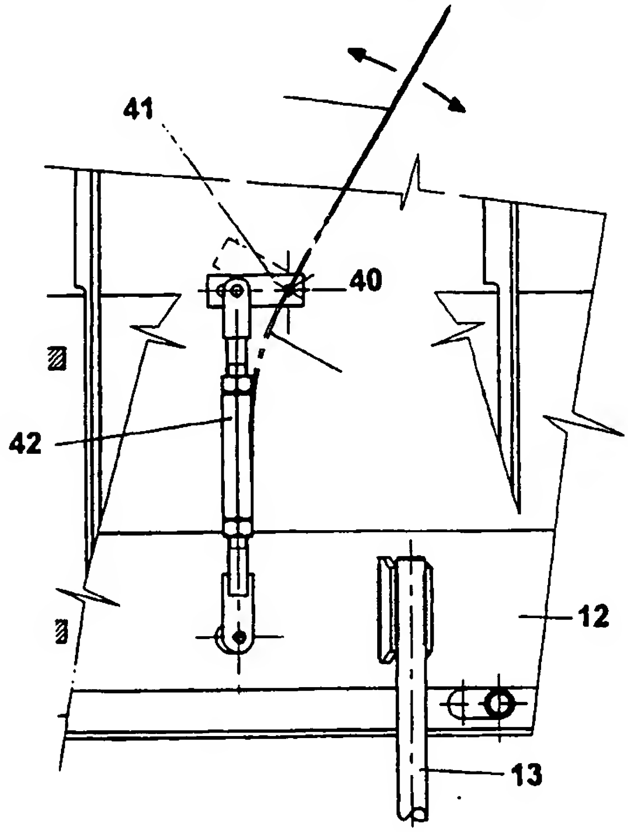
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Fig. 6

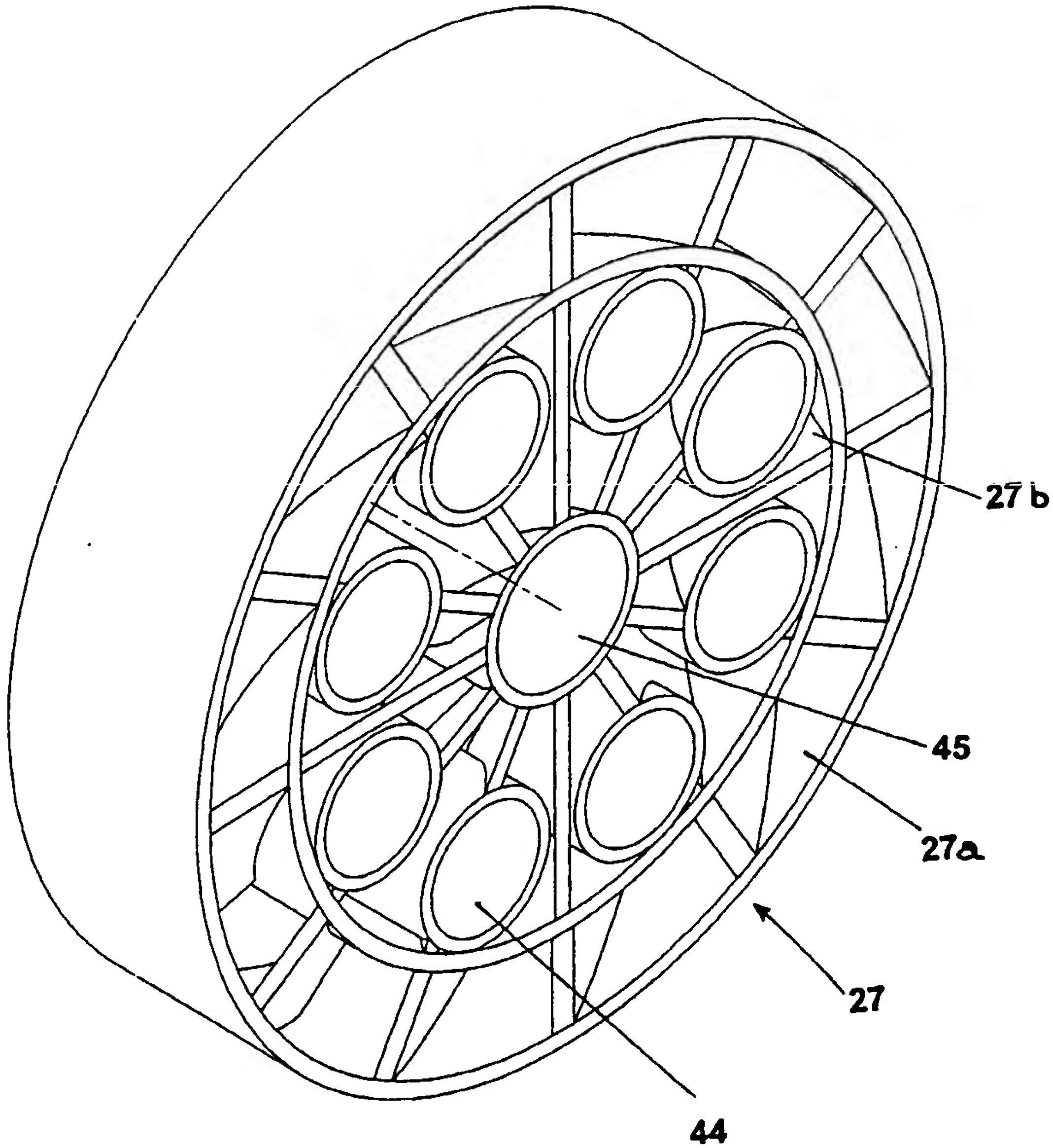

Fig. 7

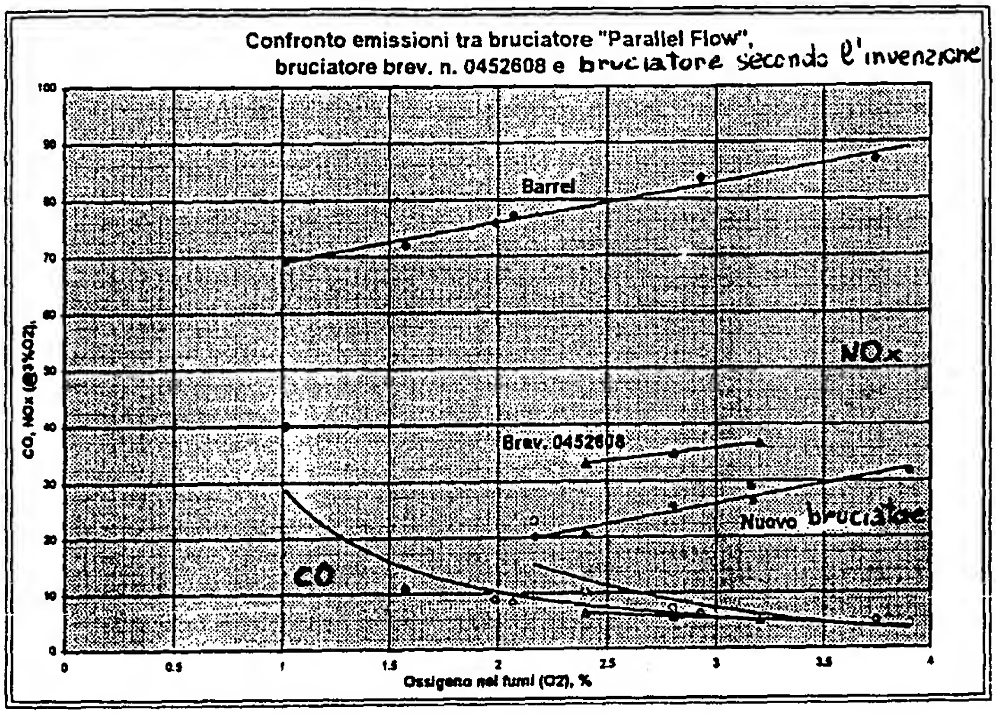
Confronto emissioni tra bruciatore "Parallel Flow",
bruciatore brev. n. 0452608 e bruciatore secondo l'invenzione
Barrel
NOx
Brev. 0452608
Nuovo bruciatore
CO
CO, NOx (@3%O2),
Ossigeno nei fumi (O2), %
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4

Fig. 8

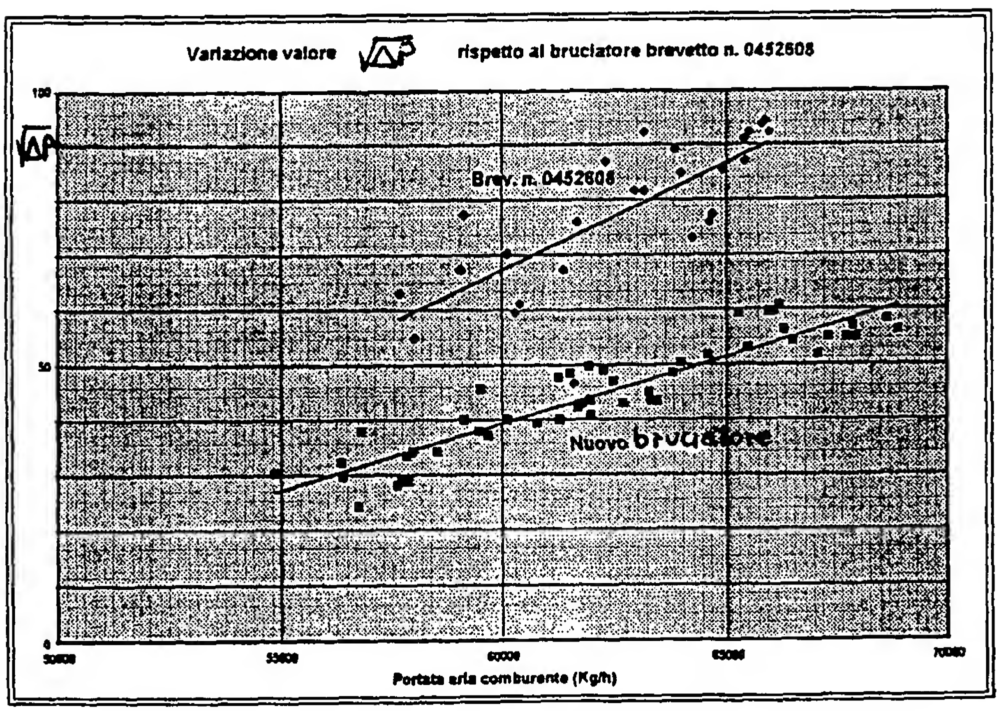
Variazione valore $\sqrt{\Delta P}$ rispetto al bruciatore brevetto n. 0452608
$\sqrt{\Delta P}$
Brev. n. 0452608
Nuovo bruciatore
Portata aria comburente (Kg/h)
100
50
0
50000
55000
60000
65000
70000

Fig. 9

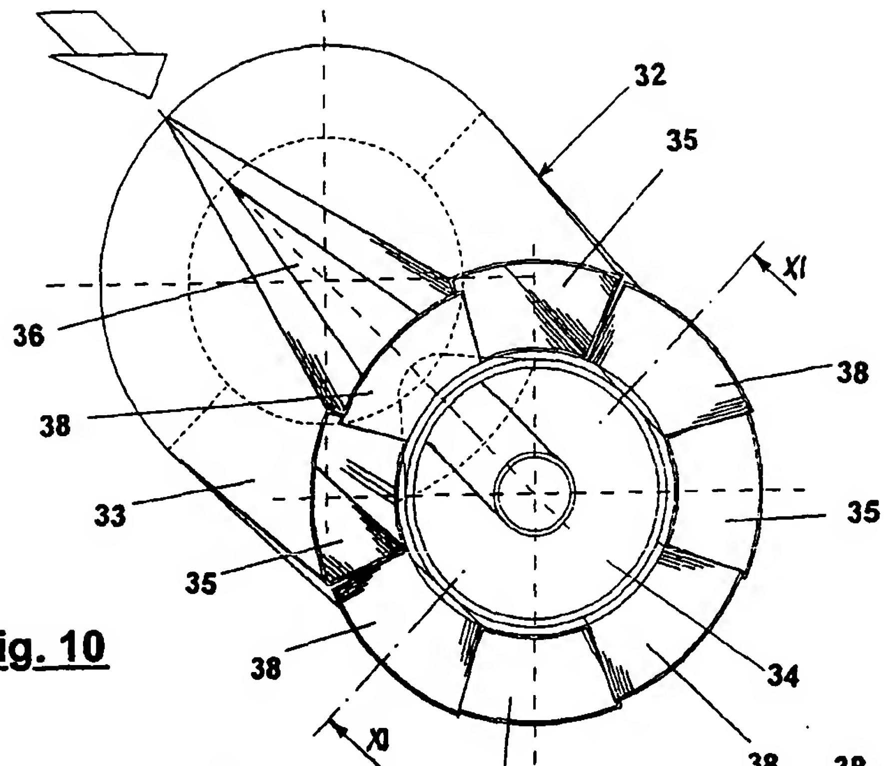

Fig. 10

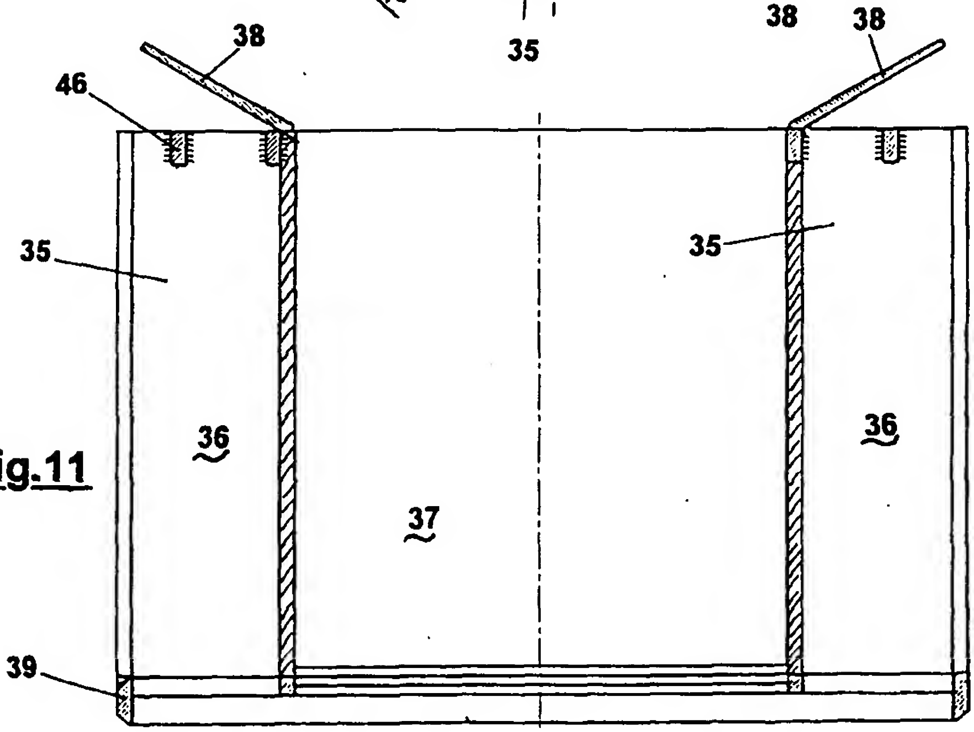

Fig.11

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 6099

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	EP 0 452 608 A (ENTE NAZ ENERGIA ELETTRICA ;ANSALDO ABB COMPONENTI S R L (IT)) 23 October 1991 * the whole document *	1	F23C7/00 F23D17/00 F23D1/02
A	EP 0 571 704 A (BABCOCK ENERGIE UMWELT) 1 December 1993 * the whole document *	1	
A	FR 2 170 451 A (HOTWORK) 14 September 1973 * the whole document *	1	
A	EP 0 163 423 A (FOSTER WHEELER ENERGY CORP) 4 December 1985 * page 11, line 13 - page 13, line 8; figures 3-5 *	12	
A	EP 0 409 102 A (BABCOCK HITACHI KK) 23 January 1991 * column 4, line 30 - column 5, line 49 * * column 6, line 51 - column 7, line 1; figures 1,6 *	12	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F23C F23D
A	EP 0 554 014 A (FOSTER WHEELER ENERGY CORP) 4 August 1993 * column 6, line 19 - column 7, line 4; figure 1 *	12	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 May 1997	Coli, E

CATEGORY OF CITED DOCUMENTS

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